

I CLAIM:

1. A control circuit for providing, in a voltage regulated circuit, a regulated voltage output from a variable voltage and frequency source in a primary circuit having at least two primary inductors in series, said control circuit comprising:
  - at least two secondary inductors associated respectively with the two primary inductors by two common saturable cores to thereby form at least two electromagnetic assemblies;
  - a saturation control unit capable of controlling a saturation level of said cores via said secondary inductors;
  - a voltage cancelling unit capable of providing an adjustable voltage source to said secondary inductors, said adjustable voltage source being out-of-phase with voltage in the voltage regulated circuit; and
  - a selection unit for selecting, depending on a feedback signal from said voltage regulation circuit, one of said saturation control unit and said voltage cancelling unit to be active to control said regulated voltage output via said electromagnetic assemblies.
2. The control circuit as claimed in claim 1, wherein said voltage output comprises a DC voltage value, and wherein said selection unit activates, depending on said DC voltage value, one of said voltage cancelling unit and said saturation control unit.

3. The control circuit as claimed in claim 2, wherein said saturation control unit is selected when said DC voltage value is smaller than a predetermined value, while said voltage cancelling unit is selected otherwise.
4. The control circuit as claimed in claim 1, wherein said feedback signal corresponds to at least one of a voltage output and a DC current value in said control circuit, and wherein said selection unit activates, depending on said DC current value, one of said voltage cancelling unit and said saturation control unit.
5. The control circuit as claimed in claim 4, wherein said saturation control unit is selected when said DC current value is larger than a predetermined value, while said voltage cancelling unit is selected otherwise.
6. The control circuit as claimed in claim 1, wherein said at least two primary inductors comprise a first inductor and a second inductor, further wherein said at least two secondary inductors comprise a third inductor and a fourth inductor, located adjacently to said first inductor and to said second inductor, further wherein said third inductor and said fourth inductor are wound about their respective cores in opposite directions relative to their respective primary inductors.
7. The control circuit as claimed in claim 1, wherein said adjustable voltage source comprises a supply

transformer connected to said variable voltage source.

8. A method for providing a regulated voltage output from a variable voltage and frequency source in a primary circuit, said method comprising:
  - obtaining a feedback signal indicative of said voltage output;
  - determining from the feedback signal whether a threshold has been reached; and
  - selecting one of a first control mode and a second control mode,

wherein the first control mode includes controlling a saturation level in at least two series saturable core inductors in the primary circuit to thereby controllably change a voltage drop across the at least two inductors, and

wherein the second control mode includes providing a variable voltage signal to secondary inductors associated via said cores with said series primary inductors, the variable voltage signal being controllably out-of-phase with the primary circuit to thereby selectively cancel at least a portion of the voltage in the primary circuit.
9. The method as claimed in claim 8, wherein said voltage output comprises a DC voltage value, and wherein said determining depends on said DC voltage value.
10. The method as claimed in claim 9, wherein said determining comprises activating said saturation

control when said DC voltage value is smaller than a predetermined value, and providing said variable voltage signal otherwise.

11. The method as claimed in claim 8, wherein said voltage output corresponds to a DC current value in said secondary inductor, and wherein said determining depends on said DC current value.
12. The method as claimed in claim 11, wherein said determining comprises activating said saturation control when said DC current value is larger than a predetermined value, and providing said variable voltage signal otherwise.
13. The method as claimed in claim 8, wherein said variable voltage signal provides two equal, but substantially opposite, voltages in said secondary inductors.
14. The method as claimed in claim 13, wherein said two equal voltages are substantially 180 degrees out-of-phase.
15. An apparatus for regulating voltage from a variable voltage and frequency source, the apparatus comprising:
  - a primary circuit including the source and at least two series primary inductors each provided on respective saturable cores; and
  - a secondary circuit including at least two series secondary inductors respectively associated with the two primary inductors via the saturable

cores, the secondary circuit further including at least a saturation apparatus communicating with the secondary inductors, a voltage cancellation apparatus communicating with the secondary inductors and a control apparatus for controlling operation of the secondary circuit,

wherein the saturation apparatus is adapted to selectively saturate the saturable cores,

wherein the voltage cancellation apparatus is adapted to selectively provide alternating current electricity to the secondary inductors which is out-of-phase with alternating current electricity in the primary circuit, and

wherein the control apparatus is adapted to control an operational status of at least one of the saturation apparatus and the voltage cancellation apparatus.

16. The apparatus of claim 15 wherein said primary series and said secondary series inductors form series primary-secondary inductor pairs wound about respective said cores, and wherein the pairs are wound in opposite directions relative to one another.
17. The apparatus of claim 15 wherein only the secondary inductor pairs are wound around the respective cores, and wherein the primary inductors merely pass adjacent the respective cores, to thereby provide a n:1 secondary-to-primary turns ratio relative to said cores.
18. The apparatus of claim 15 wherein the saturation apparatus provides a saturation signal to the

secondary inductors to thereby selectively saturate the saturable cores.

19. The apparatus of claim 15 wherein the control apparatus uses a feedback signal obtained from the primary circuit to determine said operational status.
20. The apparatus of claim 15 wherein the control apparatus permits only one of the saturation apparatus and voltage cancellation apparatus to operate on the secondary inductors at any given time.
21. An apparatus for regulating output voltage from a variable voltage and frequency source, the apparatus comprising:
  - a primary circuit including the source and at least two series primary inductors each provided on a saturable core;
  - a secondary circuit including at least two series secondary inductors respectively coupled with the two primary inductors via the saturable cores to provide two series inductor pairs;
  - a first apparatus in the second circuit for regulating the voltage in the primary circuit via the coupled series inductor pairs, the first apparatus adapted to controllably reduce an output voltage of the primary circuit to a desired output level;
  - a second apparatus in the second circuit for regulating the voltage in the primary circuit via the coupled series inductor pairs, the second apparatus adapted to controllably increase the

output voltage of the primary circuit to a desired output level; and

a selector apparatus adapted to determine when said first and second apparatus are active.

22. The apparatus of claim 21 wherein said primary series and said secondary series inductors form series inductors pairs wound about respective said cores, and wherein the pairs are wound in opposite directions relative to one another.

23. An apparatus for regulating output voltage from a variable speed permanent magnet generator when connected to a variable load system, the apparatus comprising:

first electronic means for automatically reducing the output voltage to a desired output level;

second electronic means for automatically increasing the output voltage to a desired output level; and

a selector apparatus adapted to determine which of said first and second electronic means is active at a given time.

24. A method of regulating the voltage in a primary circuit having a variable voltage and frequency electrical power source, the method comprising the steps of:

providing at least two series-connected primary inductors in the primary circuit, the primary inductors having respective saturable cores;

providing a secondary circuit having at least two series-connected secondary inductors, the

secondary inductors each respectively electromagnetically coupled with said primary inductors via said saturable cores;

selectively saturating said cores to produce a desired voltage drop across the primary inductors to thereby regulate the voltage in the primary circuit; and

selectively providing a cancellation voltage to the secondary inductors to thereby regulate the voltage in the primary circuit.

25. The method of claim 24 wherein only one of the steps of selectively saturating said cores and selectively providing a cancellation voltage is performed at any given time.
26. The method of claim 24 wherein the step of selectively saturating said cores includes providing a saturation current to the secondary inductors.
27. The method of claim 24 wherein the steps of selectively providing a cancellation voltage includes providing an alternating current voltage to the secondary inductors which is opposite in phase to an alternating current voltage in the primary circuit.
28. The method of claim 24 wherein the step of selectively saturating said cores includes increasing an output voltage of the primary circuit to a nominal output level.
29. The method of claim 24 wherein the steps of selectively providing a cancellation voltage includes

decreasing an output voltage of the primary circuit to a nominal output level.

30. The method of claim 24 wherein the steps of providing secondary inductors coupled with the primary inductors includes the step of coupling the inductors such that a first primary-secondary pair is wound about its respective core in an opposite direction to a direction which the other primary-secondary pair is wound about its respective core.